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(54) **IMPROVED ELECTRODE FOR A PLASMA ARC CUTTING SYSTEM AND OPERATIONAL METHOD**

VERBESSERTE ELEKTRODE FÜR EIN PLASMALICHTBOGENSCHNEIDSYSTEM UND BETRIEBSVERFAHREN

ÉLECTRODE AMÉLIORÉE POUR SYSTÈME DE COUPE À L'ARC PLASMA ET PROCÉDÉ DE FONCTIONNEMENT

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Description

FIELD OF THE INVENTION

[0001] The invention relates generally to the field of plasma arc cutting systems and processes. More specifically, the invention relates to improved electrodes and operational methods for cooling a plasma arc torch.

BACKGROUND

[0002] Plasma arc torches are widely used in the cutting and marking of materials. A plasma arc torch generally includes an electrode and a nozzle having a central exit orifice mounted within a torch body, electrical connections, passages for cooling, and passages for arc control fluids (e.g., plasma gas). The torch produces a plasma arc, i.e., a constricted ionized jet of a gas with high temperature and high momentum. Gases used in the torch can be non-reactive (e.g., argon or nitrogen) or reactive (e.g., oxygen or air). During operation, a pilot arc is first generated between the electrode (cathode) and the nozzle (anode). Generation of the pilot arc can be by means of a high frequency, high voltage signal coupled to a DC power supply and the torch or by means of any of a variety of starting methods.

[0003] Current plasma arc torches utilize electrodes having either one or two sealing members (e.g., o-rings) for providing fluid seals within the torch during operation, e.g., to prevent liquids and/or gases from entering certain regions of the torch. One example of such a configuration is in U.S. Patent No. 8,338,740. In most prior art torches, the first contact of the plasma gas with the electrode body is downstream of the swirl ring, so the plasma gas is already swirling when it makes this first contact. What would be beneficial would be an electrode that allows some of the complexity of gas flow to be moved closer to the electrode body, permitting a shorter electrode body to be used in modern complex torches. US2010/078408 A1 discloses an example of an electrode for a liquid cooled plasma arc torch.

SUMMARY OF THE INVENTION

[0004] The present invention relates to systems and methods for improved electrodes for plasma arc torches and associated methods of directing fluid flow and cooling consumables in plasma arc torches. In one aspect, the invention features an electrode for a liquid cooled plasma arc torch, according to claim 1. The present electrode allows some of the complexity of gas flow to be moved closer to the electrode. This allows for more gas flow complexity to be added to a torch without requiring longer torch electrodes. Also, in certain embodiments, the present torch can have an axial swirl and/or an axial flow. Locating the complexity in the interface between the electrode and the swirl ring allows for the improved swirl designs to be used in the torch.

[0005] In some embodiments, the first sealing element provides a liquid seal. In some embodiments, the first sealing element seals the exterior of the electrode body from a coolant directed to an interior surface of the electrode. In some embodiments, the second sealing element forms a first end of the swirl gas chamber, the first end configured to force a swirl gas through an opening of the swirl ring. In some embodiments, the third sealing element seals an end of the swirl gas chamber such that the swirl gas is forced through swirl holes in the swirl ring. In some embodiments, the electrode includes a quick-lock thread located near the first end of the body. In some embodiments, one or more of the sealing elements are o-rings. In some embodiments, the sealing elements are portions of chambers of the plasma arc torch.

[0006] In a second aspect, the invention features a method of directing a plasma gas flow in a liquid cooled plasma arc torch, according to claim 9.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The foregoing discussion will be understood more readily from the following detailed description of the invention when taken in conjunction with the accompanying drawings.

Figure 1 is an isometric view of an electrode having three sealing elements, according to an illustrative embodiment of the invention.

Figure 2 is a cross-sectional view of a plasma arc torch having an electrode with three sealing members, where the electrode defines a portion of a swirl chamber, according to an illustrative embodiment of the invention.

Figure 3 is a schematic diagram of a method of directing a plasma gas flow in a liquid cooled plasma arc torch, according to an illustrative embodiment of the invention.

DETAILED DESCRIPTION OF THE DRAWINGS

[0008] Figure 1 is an isometric view of an electrode 100 having three sealing elements 124, 128, 132, according to an illustrative embodiment of the invention. The electrode 100 includes a body 104 having a longitudinal axis 108 defining a first end 112, a second end 116, and a middle portion 120 between the first end 112 and the second end 116. The electrode 100 includes a first sealing element (or sealing member) 124, a second sealing element 128, and a third sealing element 132, each sealing element 124, 128, 132 positioned along the longitudinal axis 108 of the electrode 100. The first sealing element (or sealing member) 124 is disposed on the exterior of the electrode body 104 near the first end 112. The second sealing element 108 is disposed on the exterior of the electrode body 104 and is located in the middle portion 120 between the first sealing element 124 and the second end 116 along the longitudinal axis 108. When

installed in a plasma arc torch, the second sealing element 128 is configured to define a portion of a swirl gas chamber (e.g., the swirl gas chamber 212 shown and described below in Figure 2) and to provide a first gas seal to the swirl gas chamber. The third sealing element 132 is disposed on the exterior of the electrode body 104 and is located between the second sealing element 128 and the second end 116 along the longitudinal axis 108. The third sealing element 132 is configured to define a portion of the swirl gas chamber (e.g., the swirl gas chamber 212 shown and described below in Figure 2) and to provide a second gas seal to the swirl gas chamber.

[0009] Each sealing element 124, 128, 132 defines a sealing surface and a different section of the electrode 100 over which a fluid flows when installed in the plasma arc torch (e.g., the plasma arc torch 200 shown and described below in Figure 2). The first sealing element 124 seals the exterior of the electrode 104 from liquid coolants that are directed to the interior of the electrode 100 and around the threads 136. The second sealing element 128 forms a first end of the swirl gas chamber (e.g., the swirl gas chamber 212 shown and described below in Figure 2). The third sealing element 132 seals the second end of the swirl gas chamber. Thus, the second sealing element 128 and the third sealing element 132 each define boundaries of the swirl gas chamber. In some embodiments, the sealing elements 124, 128, 132 are o-rings.

[0010] As can be seen in Figure 1 (and correspondingly in Figure 2 below), each sealing element 124, 128, 132 is placed on an exterior surface of the electrode body 104 that has a different diameter. In Figure 1, the first sealing element 124 is on the surface having the largest of the three diameters. The second sealing element 128 is on a surface having an intermediate diameter, and the third sealing element 132 is on a surface having the smallest diameter. In some embodiments, this "tapered" configuration eases assembly of the electrode 100 with the swirl ring within the torch body. Moreover, the threads 136 (e.g., a "quick lock" thread feature) allow the electrode 100 to be fully axially assembled into the torch and rotated to engage the threads 136. In such a configuration, the mechanical advantage of the threads 136 cannot be used to force the sealing elements 124, 128, 132 into corresponding openings in the torch body. Therefore, the "tapered" configuration having different diameters of the electrode body 104 allows the electrode sealing elements 124, 128, 132 to engage with and slide against the adjacent components only for a short distance, reducing the force required to assemble the torch components.

[0011] Figure 2 is a cross-sectional view of a plasma arc torch 200 having an electrode 204 with a longitudinal axis 208 and three sealing members 224, 228, 232, the electrode 204 defining a portion of a swirl chamber 212, according to an illustrative embodiment of the invention. When installed in the plasma arc torch 200, the electrode 204 engages with the swirl ring 216, and the sealing members 224, 228, 232 define various boundaries within the plasma arc torch 200. For example, the first sealing member 224 defines a water cooling boundary that seals the exterior surface of the electrode 204 a coolant directed to an interior surface of the electrode 204. The second sealing member 228 defines a first (or "metering" as explained below) boundary of the swirl gas chamber 212. The third sealing member 232 defines a second (or "swirling" as explained below) boundary of the swirl gas chamber 212. Thus, a portion of the swirl gas chamber 212 is defined by the second sealing member 228 and the third sealing member 232, together with the section of electrode wall 236 located between the second sealing member 228 and the third sealing member 232.

[0012] During operation of the plasma arc torch 200, swirl gas travels along a flow path 240 past the first sealing member 224 along an exterior surface 244 of the electrode 204. The swirl gas (or plasma gas) enters in the open rear chamber of the swirl ring 216. The rear chamber is defined as the gap between the interior of the swirl ring 216, the exterior surface 244 of the electrode, and the second sealing member 228. Once the swirl gas enters into the rear chamber it next directed through openings 248 as the second sealing member 228 prevents the gas from flow forward. Opening 248 extending from the interior of the swirl ring 216 to the exterior of the swirl ring and is oriented radially (e.g., orthogonally to the longitudinal axis 208) and flows into a torch passageway 252. The torch passageway is defined by the exterior of the electrode, and swirl gas continues along fluid flow path 240 toward a first end 212A of the swirl gas chamber 212 through metering holes (e.g. metering hole 256) in the swirl ring 216. The metering holes meter the swirl gas flow from the exterior of the swirl ring 216 into the swirl gas chamber 212. Swirl gas then flows onto a second end 212B of the swirl gas chamber 212 through an opening and to the outside of the swirl ring. The third sealing element 232 seals the second end 212B of the swirl gas chamber 212 such that swirl gas is forced through the swirl holes (not visible) in the front of the swirl ring and into the plasma plenum 254. Thus, the second sealing member 228 and the third sealing member 232 define a swirl gas chamber 212 that receives plasma gas from metering holes and discharges plasma gas through swirl holes. In some embodiments, it is beneficial to maintain separate swirl holes and metering holes because each set of holes performs a separate function requiring a different corresponding structure.

[0013] Figure 3 is a schematic diagram of a method 300 of directing a plasma gas flow in a liquid cooled plasma arc torch, according to an illustrative embodiment of the invention. The method 300 includes a step 310 providing an electrode having a first liquid sealing member, a first gas sealing member, and a second gas sealing member. The method 300 includes a step 320 of flowing a plasma gas about an exterior surface of the electrode into a channel. The method 300 includes a step 330 of directing the plasma gas flow from the channel into a chamber, the chamber defined in part by the first gas sealing member and the second gas sealing member.

The method 300 includes a step 340 of directing the plasma gas flow through a set of swirl holes of the chamber and onto a workpiece.

[0014] While the invention has been particularly shown and described with reference to specific preferred embodiments, it should be understood by those skilled in the art that various changes in from and detail may be made therein without departing from the scope of the invention as defined by the following claims.

Claims

1. An electrode (100,200) for a liquid cooled plasma arc torch, the electrode comprising:

   a body (104,204) having a longitudinal axis defining a first end, a second end, and a middle portion between the first and second ends;
   a first sealing element (124,224) disposed on an exterior of the body near the first end;
   a second sealing element (128,228) disposed on the exterior of the body, the second sealing element located in the middle portion between the first sealing element and the second end along the longitudinal axis, the second sealing element configured to provide a first gas seal to a swirl gas chamber (212) and defining a portion of the swirl gas chamber; and
   a third sealing element (132,232) disposed on the exterior of the body, the third sealing element located between the second sealing element and the second end along the longitudinal axis, the third sealing element configured to provide a second gas seal to the swirl gas chamber and defining a portion of the swirl gas chamber,
   characterised in that
   a diameter of the first sealing element is larger than a diameter of the second sealing element and a diameter ofthe second sealing element is larger than a diameter of the third sealing element; and
   the electrode has a tapered shape configured to allow the electrode sealing elements to engage with and slide against adjacent components of the plasma arc torch such that a force required to assemble the electrode in the torch is reduced.

2. The electrode of claim 1 wherein the first sealing element provides a liquid seal.

3. The electrode of claim 1 wherein the first sealing element seals the exterior of the electrode body from a coolant directed to an interior surface of the electrode.

4. The electrode of claim 1 wherein the second sealing element forms a first end of the swirl gas chamber, the first end configured to force a swirl gas through an opening of the swirl ring.

5. The electrode of claim 1 wherein the third sealing element seals an end of the swirl gas chamber such that the swirl gas is forced through swirl holes in the swirl ring.

6. The electrode of claim 1 further comprising a quick-lock thread located near the first end of the body.

7. The electrode of claim 1 wherein one or more of the sealing elements are o-rings.

8. The electrode of claim 1 wherein the sealing elements are portions of chambers of the plasma arc torch.

9. A method of directing a plasma gas flow in a liquid cooled plasma arc torch, the method comprising:

   providing an electrode according to claim 1;
   flowing a plasma gas about an exterior surface of the electrode into a channel;
   directing the plasma gas flow from the channel into the swirl gas chamber, the swirl gas chamber defined in part by the second sealing member and the third sealing member; and
   directing the plasma gas flow through a set of swirl holes of the swirl gas chamber and onto a workpiece.

Patentansprüche

1. Elektrode (100,200) für einen flüssigkeitsgekühlten Plasmalichtbogenbrenner, wobei die Elektrode umfasst:

   einen Körper (104,204) mit einer Längsachse, die ein erstes Ende, ein zweites Ende und einen mittleren Abschnitt zwischen dem ersten und dem zweiten Ende definiert;
   ein erstes Dichtungselement (124,224), das auf einer Außenseite des Körpers nahe dem ersten Ende angeordnet ist;
   ein zweites Dichtungselement (128,228), das auf der Außenseite des Körpers angeordnet ist, wobei sich das zweite Dichtungselement entlang der Längsachse in dem mittleren Abschnitt zwischen dem ersten Dichtungselement und dem zweiten Ende befindet, wobei das zweite Dichtungselement dazu ausgelegt ist, eine erste Gasdichtung zu einer Wirbelgaskammer (212) bereitzustellen, und einen Abschnitt der Wirbelgaskammer definiert; und
   ein drittes Dichtungselement (132,232), das auf

der Außenseite des Körpers angeordnet ist, wobei sich das dritte Dichtungselement entlang der Längsachse zwischen dem zweiten Dichtungselement und dem zweiten Ende befindet, wobei das dritte Dichtungselement dazu ausgelegt ist, eine zweite Gasdichtung zu der Wirbelgaskammer bereitzustellen, und einen Abschnitt der Wirbelgaskammer definiert, **dadurch gekennzeichnet, dass** ein Durchmesser des ersten Dichtungselements größer als ein Durchmesser des zweiten Dichtungselements ist und ein Durchmesser des zweiten Dichtungselements größer als ein Durchmesser des dritten Dichtungselements ist; und
die Elektrode eine verjüngte Form aufweist, die dazu ausgelegt ist, zu ermöglichen, dass die Dichtungselemente der Elektrode mit angrenzenden Komponenten des Plasmalichtbogenbrenners in Eingriff kommen und derart daran gleiten, dass eine zum Montieren der Elektrode in dem Brenner erforderliche Kraft reduziert wird.

2. Elektrode nach Anspruch 1, wobei das erste Dichtungselement eine Flüssigkeitsdichtung bereitstellt.

3. Elektrode nach Anspruch 1, wobei das erste Dichtungselement die Außenseite des Elektrodenkörpers von einem Kühlmittel abdichtet, das auf eine Innenfläche der Elektrode geleitet wird.

4. Elektrode nach Anspruch 1, wobei das zweite Dichtungselement ein erstes Ende der Wirbelgaskammer bildet, wobei das erste Ende dazu ausgelegt ist, ein Wirbelgas durch eine Öffnung des Wirbelrings zu drücken.

5. Elektrode nach Anspruch 1, wobei das dritte Dichtungselement ein Ende der Wirbelgaskammer derart abdichtet, dass das Wirbelgas durch Wirbellöcher in dem Wirbelring gedrückt wird.

6. Elektrode nach Anspruch 1, ferner umfassend ein Schnellverschlussgewinde, das sich nahe dem ersten Ende des Körpers befindet.

7. Elektrode nach Anspruch 1, wobei eines oder mehrere der Dichtungselemente O-Ringe sind.

8. Elektrode nach Anspruch 1, wobei die Dichtungselemente Abschnitte von Kammern des Plasmalichtbogenbrenners sind.

9. Verfahren zum Leiten einer Plasmagasströmung in einem flüssigkeitsgekühlten Plasmalichtbogenbrenner, wobei das Verfahren umfasst:

Bereitstellen einer Elektrode nach Anspruch 1;
Strömen eines Plasmagases um eine Außenfläche der Elektrode in einen Kanal;
Leiten der Plasmagasströmung von dem Kanal in die Wirbelgaskammer, wobei die Wirbelgaskammer teilweise durch das zweite Dichtungselement und das dritte Dichtungselement gebildet wird; und
Leiten der Plasmagasströmung durch einen Satz von Wirbellöchern der Wirbelgaskammer und auf ein Werkstück.

Revendications

1. Électrode (100, 200) pour un chalumeau à arc plasma refroidi par liquide, l'électrode comprenant :

un corps (104, 204) ayant un axe longitudinal définissant une première extrémité, une seconde extrémité, et une partie médiane entre les première et seconde extrémités ; un premier élément d'étanchéité (124, 224) disposé sur un extérieur du corps près de la première extrémité ;
un deuxième élément d'étanchéité (128, 228) disposé sur l'extérieur du corps, le deuxième élément d'étanchéité étant situé dans la partie médiane entre le premier élément d'étanchéité et la seconde extrémité le long de l'axe longitudinal, le deuxième élément d'étanchéité étant configuré pour fournir une première étanchéité aux gaz à une chambre de gaz de tourbillon (212) et définissant une partie de la chambre de gaz de tourbillon ; et
un troisième élément d'étanchéité (132, 232) disposé sur l'extérieur du corps, le troisième élément d'étanchéité étant situé entre le deuxième élément d'étanchéité et la seconde extrémité le long de l'axe longitudinal, le troisième élément d'étanchéité étant configuré pour fournir une seconde étanchéité aux gaz à la chambre de gaz de tourbillon et définissant une partie de la chambre de gaz de tourbillon, **caractérisée en ce que**
un diamètre du premier élément d'étanchéité est plus grand qu'un diamètre du deuxième élément d'étanchéité et un diamètre du deuxième élément d'étanchéité est plus grand qu'un diamètre du troisième élément d'étanchéité ; et
l'électrode a une forme effilée configurée pour permettre aux éléments d'étanchéité d'électrode d'entrer en prise avec, et de coulisser contre, des composants adjacents du chalumeau à arc plasma de telle sorte qu'une force requise pour assembler l'électrode dans le chalumeau soit réduite.

2. Électrode de la revendication 1, dans laquelle le pre-

mier élément d'étanchéité fournit une étanchéité aux liquides.

3. Électrode de la revendication 1, dans laquelle le premier élément d'étanchéité rend étanche l'extérieur du corps d'électrode à un fluide de refroidissement guidé vers une surface intérieure de l'électrode.

4. Électrode de la revendication 1, dans laquelle le deuxième élément d'étanchéité forme une première extrémité de la chambre de gaz de tourbillon, la première extrémité étant configurée pour forcer un gaz de tourbillon à travers une ouverture de l'anneau de tourbillon.

5. Électrode de la revendication 1, dans laquelle le troisième élément d'étanchéité rend étanche une extrémité de la chambre de gaz de tourbillon de telle sorte que le gaz de tourbillon soit forcé à travers des trous de tourbillon dans l'anneau de tourbillon.

6. Électrode de la revendication 1, comprenant en outre un filetage à verrouillage rapide situé près de la première extrémité du corps.

7. Électrode de la revendication 1, dans laquelle un ou plusieurs des éléments d'étanchéité sont des joints toriques.

8. Électrode de la revendication 1, dans laquelle les éléments d'étanchéité sont des parties de chambres du chalumeau à arc plasma.

9. Procédé de guidage d'un écoulement de gaz plasma dans un chalumeau à arc plasma refroidi par liquide, le procédé comprenant :

la fourniture d'une électrode selon la revendication 1 ; la mise en écoulement d'un gaz plasma, autour d'une surface extérieure de l'électrode, dans un canal ;
le guidage de l'écoulement de gaz plasma, depuis le canal, dans la chambre de gaz de tourbillon, la chambre de gaz de tourbillon étant définie en partie par le deuxième élément d'étanchéité et le troisième élément d'étanchéité ; et
le guidage de l'écoulement de gaz plasma à travers un ensemble de trous de tourbillon de la chambre de gaz de tourbillon, et sur une pièce à travailler.

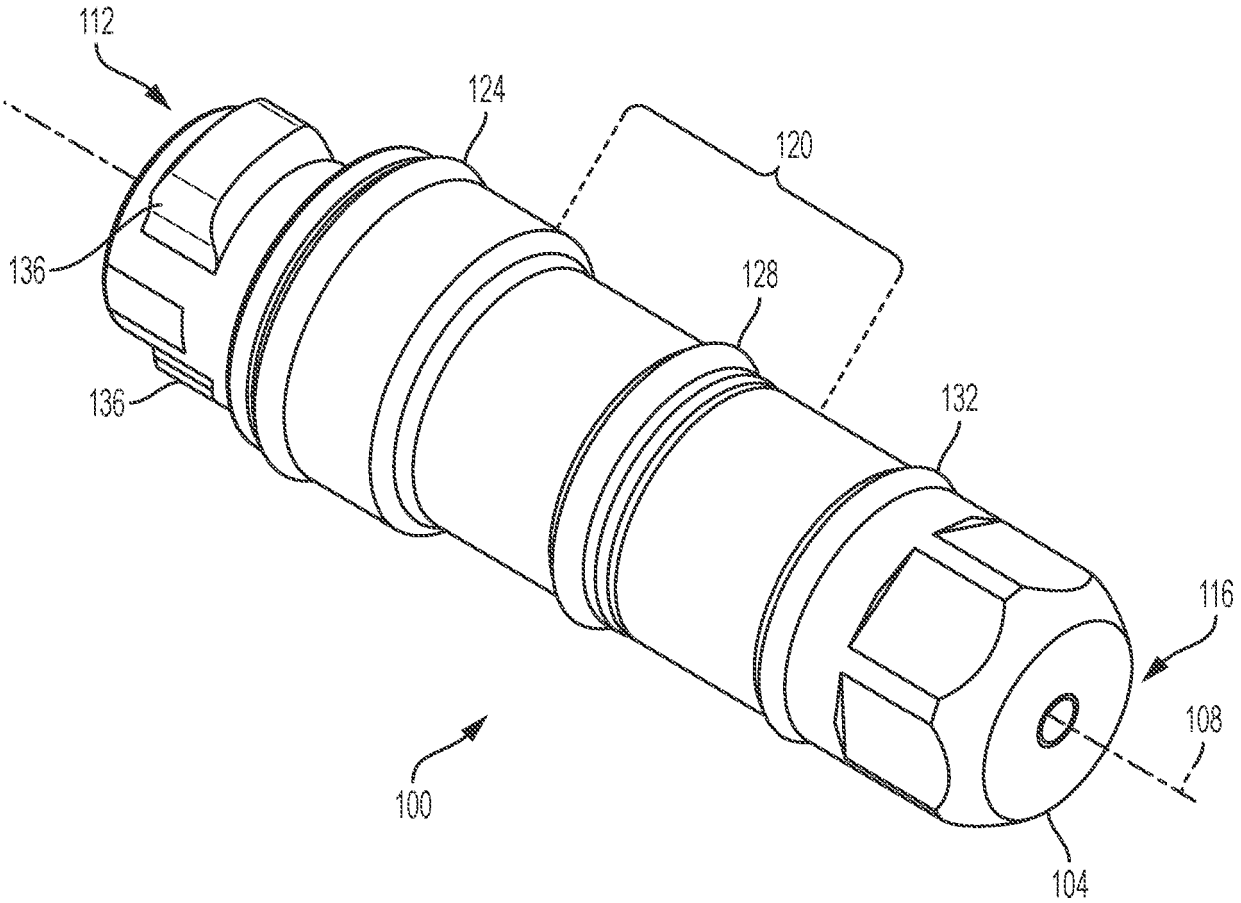

FIG. 1

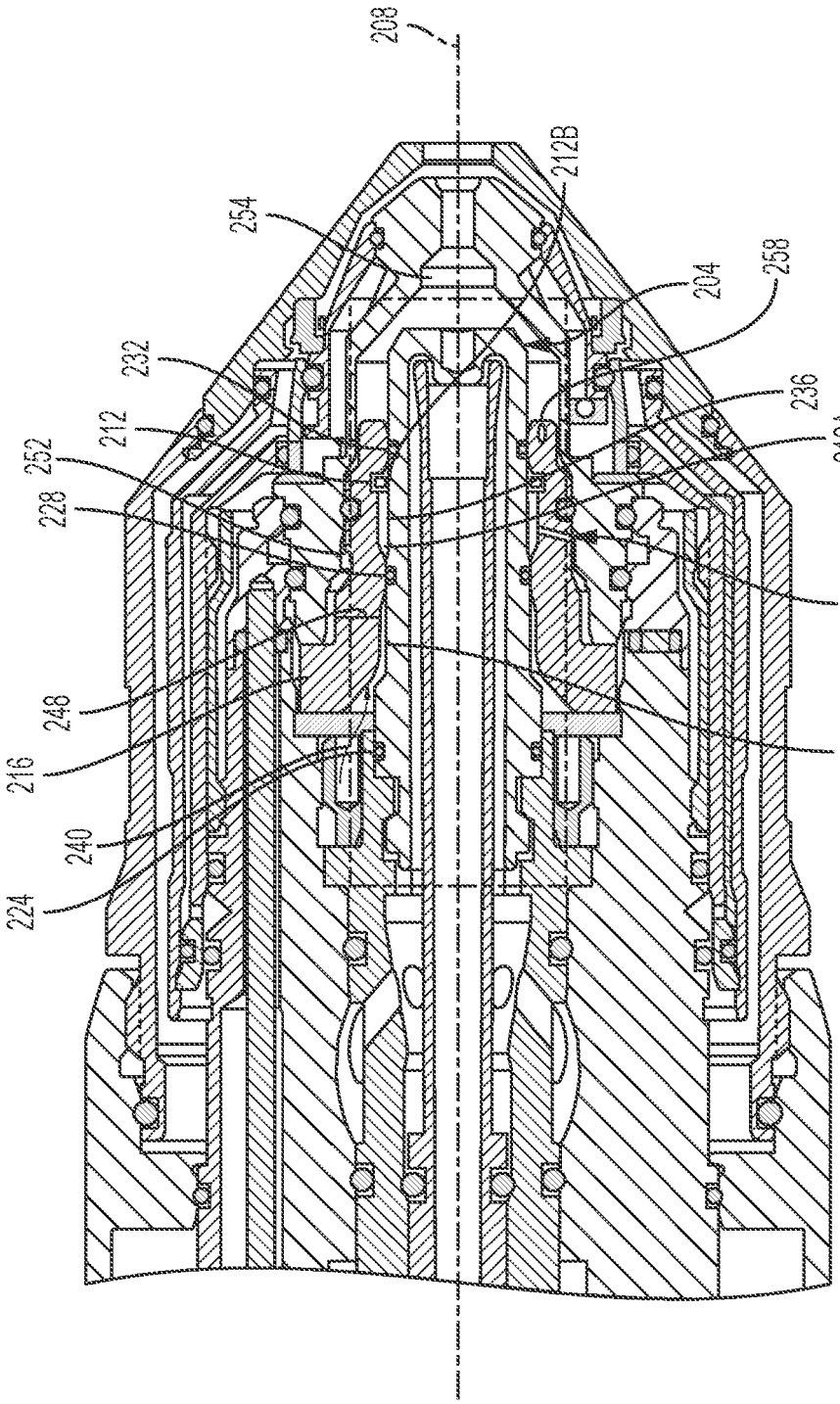
208
212B
254
204
258
232
236
212
212A
252
228
256
248
244
216
240
224
200

FIG. 2

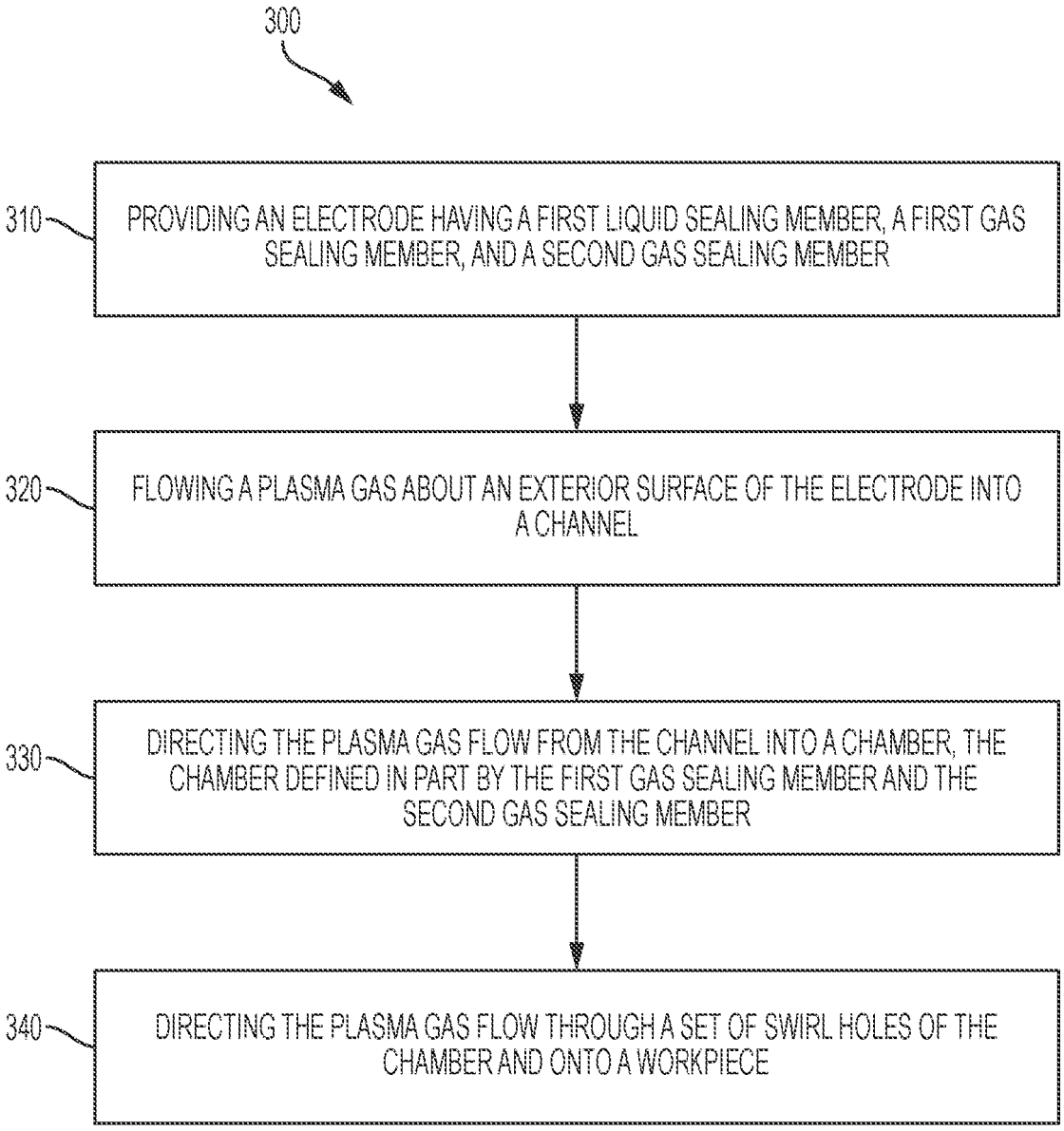
300
310
PROVIDING AN ELECTRODE HAVING A FIRST LIQUID SEALING MEMBER, A FIRST GAS SEALING MEMBER, AND A SECOND GAS SEALING MEMBER
320
FLOWING A PLASMA GAS ABOUT AN EXTERIOR SURFACE OF THE ELECTRODE INTO A CHANNEL
330
DIRECTING THE PLASMA GAS FLOW FROM THE CHANNEL INTO A CHAMBER, THE CHAMBER DEFINED IN PART BY THE FIRST GAS SEALING MEMBER AND THE SECOND GAS SEALING MEMBER
340
DIRECTING THE PLASMA GAS FLOW THROUGH A SET OF SWIRL HOLES OF THE CHAMBER AND ONTO A WORKPIECE

FIG. 3

REFERENCES CITED IN THE DESCRIPTION

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